LASER TECHNOLOGY PART --I

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COHERENCE

- A wave which appears to be a pure sine wave for an infinitely large period of time.

- There is a definite relationship between the phase of the wave at a given time and a certain time later.

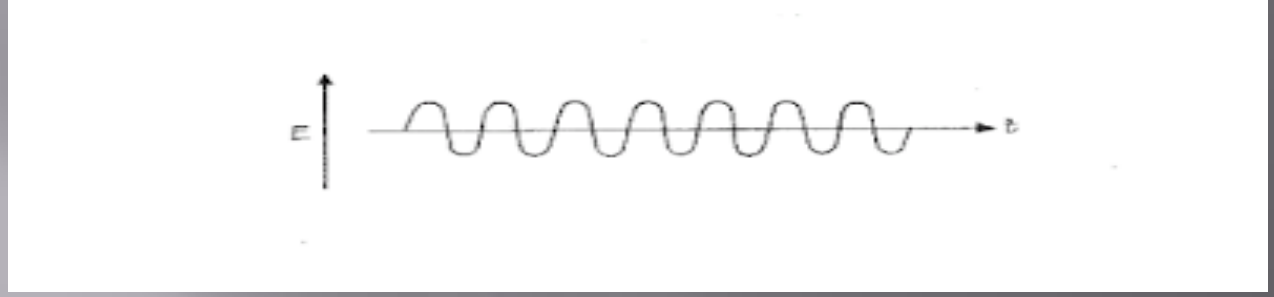
- No light source emits a perfectly coherent wave.

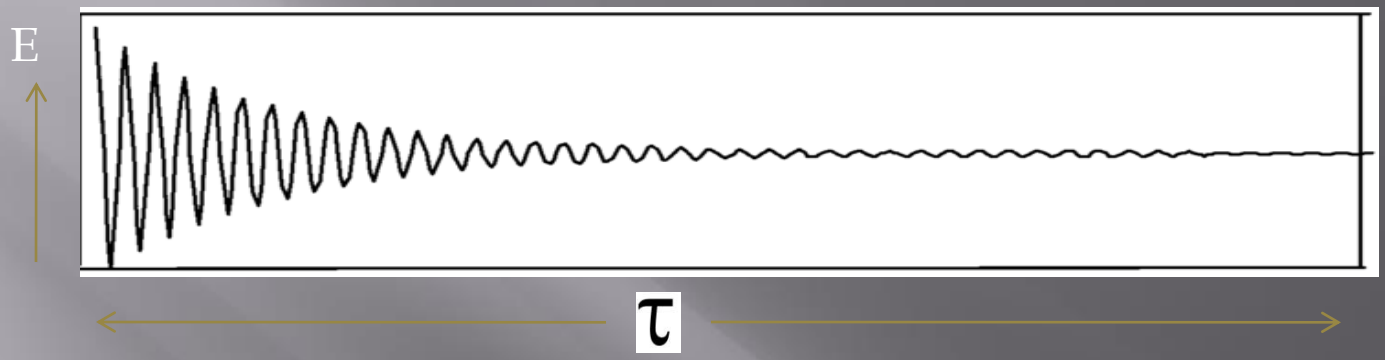
- Light wave which are pure sine waves only for a limited period of time or space are partially coherent waves.

Types of Coherence

(1) Temporal coherence

- The oscillating electric field 'E' of a perfectly coherent light wave would have a constant amplitude of vibration at any point.
- While its phase would vary linearly with time.
- As a function of time, the field would appear an ideal sinusoidal function of time.
- No light emitted by an actual source produces an ideal sinusoidal field for all values of time.
- The average time-interval for which the field remains sinusoidal is known as temporal coherence of the light beam.



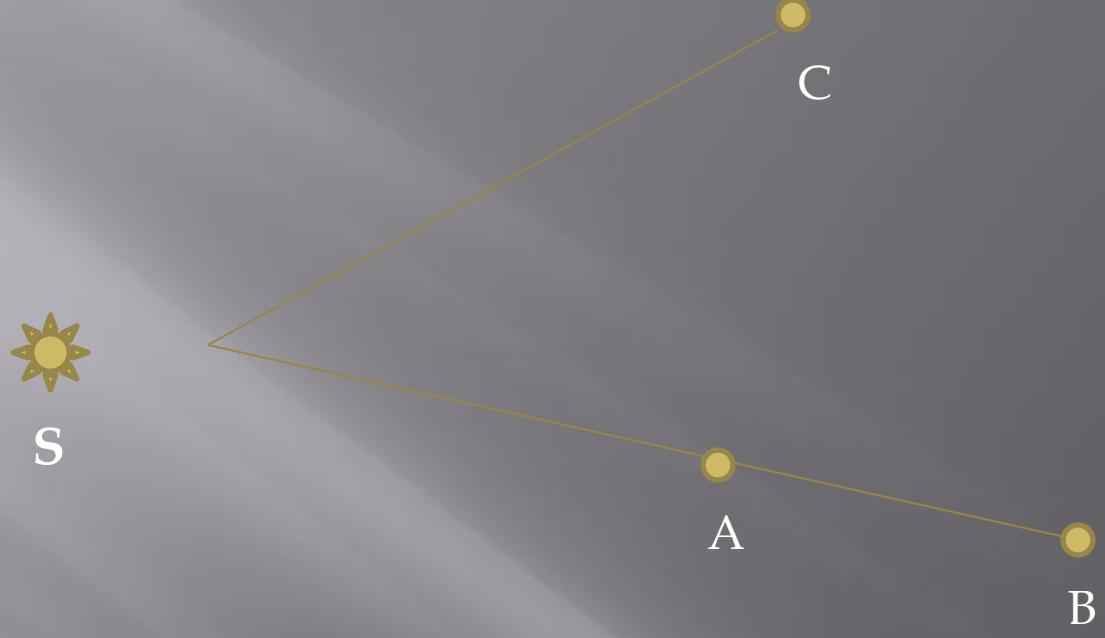


The average time interval for which the field remains sinusoidal is known as coherence time or temporal coherence of the light beam and is denoted by τ . The distance L for which the field is sinusoidal is given by:

$$L = \tau \; c$$

(2) Spatial Coherence

- It is the phase relationship between the radiation fields at different points in space.
- Two points A & B lying on a line joining them with source S.
- Phase difference between two points A & B depends on the distance and on the temporal coherence of the beam.



If AB << L (coherence length), there will be a definite phase relationship between A & B, i.e. there will be high coherence between A & B. on the other hand, if AB >> L, there will be no coherence between A & B.

POPULATION INVERSION

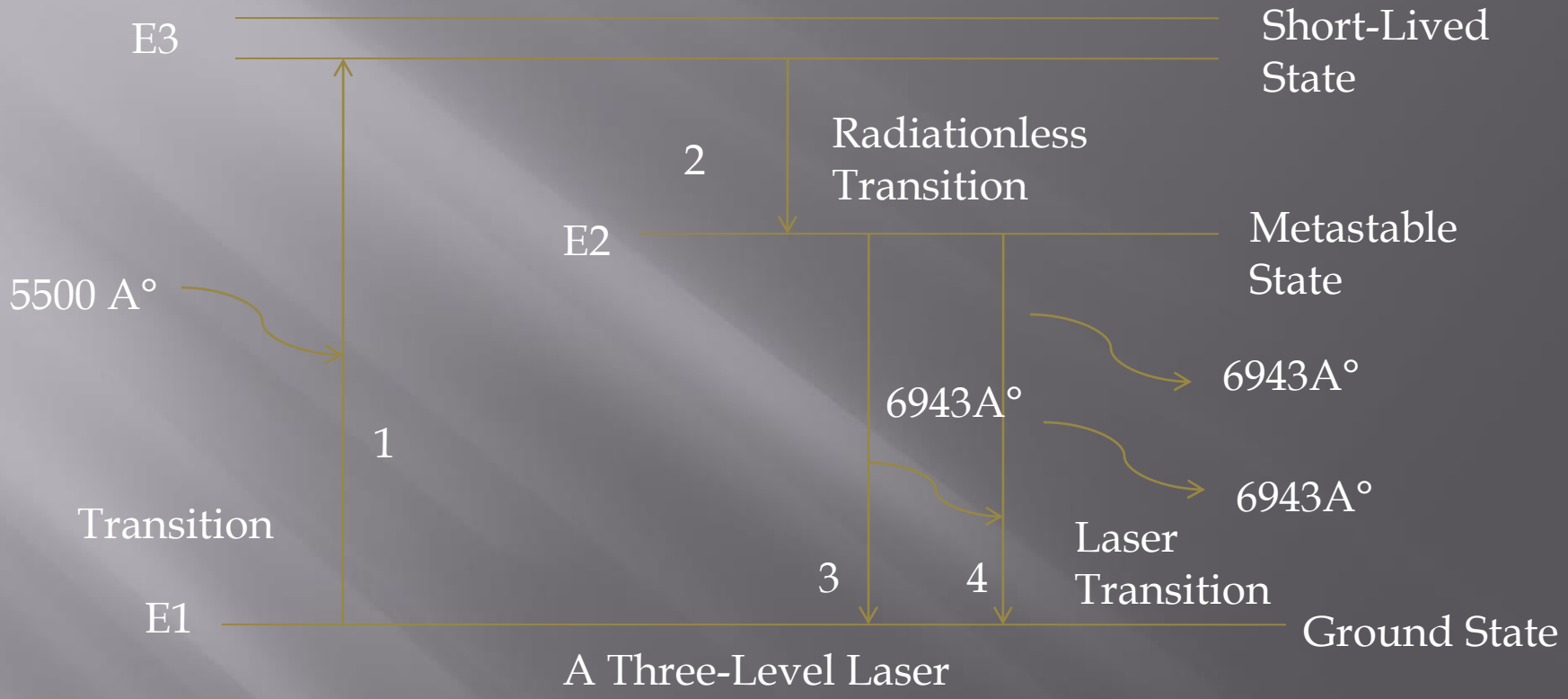
- Normally in thermal equilibrium, the number of atoms in the higher energy state (N2) is considerably smaller than the number in the lower energy state (N1).
- There is very little stimulated emission compared with absorption.
- The atoms be initially excited so that there are more atoms in the higher energy state.
- This is known as population inversion.

PUMPING

- Method of producing population inversion is called pumping.
- The population inversion can be achieved by exciting the medium with suitable form of energy.
- There are many methods of pumping a Laser and producing population inversion necessary for occurrence of stimulated emission.

1) Optical pumping

- If luminous energy is supplied to medium for causing population inversion called optical pumping.
- The luminous energy usually comes from a light source in the form of short flashes of light.
- First used in Ruby laser by Mainman and now a days used in solid state lasers.
- Laser material is simply placed inside a helical xenon flash lamp of the same type a used in photography.


E3
Short-Lived
State
2
Radiationless
Transition
E2
Metastable
State
5500 A°
6943A°
6943A°
1
6943A°
Transition
Laser
Transition
3
4
E1
Ground State
A Three-Level Laser

(2) Electric discharge

- The pumping by electric discharge is preferred in gaseous-ion lasers (e.g. Argon-ion laser).
- When a p.d. is applied between cathode and anode in discharge tube , the electrons emitted from cathode are accelerated towards anode.
- Electron collide with atoms of the active medium, ionise the medium and raise it to higher level.
- Produces population inversion and is also called direct-electron excitation.

(3) Inelastic atom-atom collisions

- In electric discharge, one type of atoms are raised to their excited states.
- These atoms collide inelastically with another type of atoms.
- It is these latter atoms which provide the population inversion needed for laser emission.
- The example is Helium Neon Laser.

(4) Direct conversion

- A direct conversion of electrical energy into radiant energy occurs in light emitting diodes (LEDs).
- The example of population inversion by direction collision occurs in semiconductor lasers.

(5) Chemical conversion

❖ Energy comes from a chemical reaction without any need for other energy sources.

❖Ex: Hydrogen can combine with flourine to form hydrogen-fluoride.

❖This is used to pump a CO2 laser to achieve population inversion.

THANK YOU

Alos see Part II & III